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Touch sensitive capacitive sensor matrix field

The invention presents a device that can determine a position coordinates of a touch. The device consists of a number of individual passive sensor elements that can be arbitrarily distributed in the form of a matrix and are based on a purely capacitive bas3e measurement effect, as well as evaluation electronics. On two orthogonal sides of the matrix made of the sensor elements, a suitable signal input takes place over the coupling resistors; the two remaining sides supply the measurement signals for the X and Y positions. Therefore, there are only three line connections between the passive sensor matrix and the evaluation electronics.

In a preferred exemplary embodiment, a microcontroller within the evaluation electronics takes over among other things the communication with possible peripheral devices, like for example PC, that need to be controlled by the device. The advantages of the invention consist in that it provides a cost effective input device based on its extremely simple, preferably single-layer design that can be well used in endangered by contamination and vandalism areas.

Description

The invention concerns a capacitive touch sensitive device that can be operated or handled by electrically non-conductive materials and is capable to locate the coordinates of a contact point created by the operator's finger or by another object. Such systems can facilitate, for example, a dialog between the operator and a computer system.

[State of Technology]

Touch sensitive, organized in a matrix form, partly also capacitive input systems are known from, for example, US patent specifications 4,550,310 and 5 463 388, as well as from the patent specification DE 197 44 791 A1. All the existing systems have in common the relatively complex design structures solving the problem of the contact point location. The described devices always have a multilayer design of the sensor surface layer and/or an expensive evaluation electronics growing with the number of rows and columns of the adopted matrix design and, therefore, with the maximum resolution of the system. In part, the devices do not work, in spite of a description as such, with a capacitive base measurement effect. Due to the multilayer construction, the application of such devices as transparent input systems in front of displays (touch screens) is extremely difficult. In the face of the above-described problems, there is a need of a simple applicable, single-layer design, capacitive, touch sensitive device containing only as many electronic components or electronic expenses as is absolutely necessary for a satisfactory position determination.

[Task of the invention]

It follows from the Stand of the Technology, that the task of the invention is the realization of a low overhead, cost effective, vandalism and wear resistant input device consisting of matrix-like distributed, touch sensitive, capacitive sensor elements, which, according to the invention, is preferably designed as a single layer of special base sensors, and can be operated with a single evaluation electronic, independently form the number of individual sensor elements.

[Examples]

In the following, exemplary embodiments of the invention will be explained in more detail based on the enclosed drawings:

Fig. 1a shows the invented, touch sensitive, geometric structure and the arrangement of a single sensor element (**1**). It consists of a suitably placed four single surfaces individually (**2**) electrically connected with a feed line (**3**).

Due to the juxtaposition of the individual surfaces (**2**) and electric quadruple pole is created with the individual quadruple pole capacities $\mathbf{C_{vp}}$ (**4**), as shown in **Fig.** 1b.

Fig. 2 shows multiple individual capacitive sensor elements (**1**) connected with each other by the supply lines (**3**) flatly placed beneath a dielectric, electrically non-conductive material (**6**) in a cross-section.

The material secures that the operator's finger or an object (**5**), which has at least parasitic capacitive connection to the ground, cannot contact directly electrically the individual capacitive sensor elements (**1**), so that in any case capacities can be created between the individual surfaces (**2**) relative to each other and the operator's finger or object (**5**), which has at least parasitic capacitive connection to the ground, and the individual surfaces (**2**).

Fig. 3a shows in the top view how an operator's finger or an object (**5**), with at least parasitic capacitive connection to the ground, is placed above an individual capacitive sensor element (**1**) covered by an electrically non-conductive material (**6**) and how it contacts the electrically non-conductive material (**6**) on its side opposite to the capacitive sensor element (**1**).

Fig. 3b shows a new electric quadruple pole with the individual quadruple pole capacities $\mathbf{C_{vp}}$ (**4**) cause by this situation and the now new additional capacities against the earth potential $\mathbf{C_p}$ (**7**).

Now, if the individual capacitive sensor elements (**1**) are matrix like flatly arranged, namely in such a way that the connections indicated by $\mathbf{C_0}$ will be connected with the connector $\mathbf{C_i}$ of the next lower element and the connections indicated by $\mathbf{R_0}$ will be connected with the connector $\mathbf{R_i}$ of the next element to the right, the result is a homogeneous, matrix arrangement of partial quadruple poles, as shown in

Fig. 4. Should there be a contact on the opposite side of a capacitive sensor element (**1**), that is on the surface of the electrically non-conductive material (**6**) facing away from the sensor elements by an operator's finger or an object (**5**), which has at least a parasitic capacitive connection to the ground, then the corresponding sensor quadruple pole in the entire arrangement from **Fig.** 4 has to be replaced by the quadruple pole

from **Fig.** 3b and the electric homogeneity of the entire flat matrix arrangement disappears.

Fig. 5 shows a preferable exemplary embodiment of touch sensitive matrix of flatly arranged, single, capacitive sensor elements (**1**). The entire four-sided, orthogonal surface of the layout is suitably supplied on two orthogonal to each other sides over the coupling resistors (**8**) from a common signal source (**9**). On both remaining sides, a common measurement signal junction for the X position (**10**) and a common measurement signal junction for the Y position (**11**) lead out again through the coupling resistors (**8**). Hence, the entire arrangement is connected by only three signal cables with the evaluation electronic (**12**), as shown in

Fig. 6. This state of the arrangement remains valid, in the likewise schematically represented in **Fig.** 6, independently from the number of the individual capacitive sensor elements (**1**) used and, therefore, avoids possible breakup of the determination of the contact coordinates. The evaluation electronics (**12**) itself preferably consists of three functional units: a supply source (**9**), an input stage (**14**) for collecting the measurement values of the X position and collecting the measurement of the Y position, as well as a microcontroller (**13**). The latter is preferably used for the execution of multiple tasks within the evaluation electronics (**12**). It controls the signal of the supply source (**9**) regarding its amplitude and/or phase position, it processes in a suitable way the data from the input stage (**14**), it calculates according to a suitable algorithm the XY position coordinates of a contact with the non-conductive material and forwards the determined position coordinates to the devices further down the line, with which a communication should be established, e.g., PC.

Fig. 7 shows a preferable exemplary embodiment of a touch sensitive, arranged flatly in a matrix, capacitive sensor elements (**1**). Hereby, the supply lines (**3**) of the individual capacitive sensor elements (**1**) were completely abandoned and placed each two adjacent, with the same electric potential, sensor electrode individual surfaces join now seamlessly together. This creates an extremely simple in manufacturing diamond structure (**15**), which can be functionally operated according to the same principle as the arrangements described in **Fig.** 5 and **Fig.** 6.

Fig. 8 shows a matrix of measurement value pairs. Each of these measurement value pairs in itself is uniquely associated with the contact position of the corresponding capacitive sensor element (**1**) within the flat matrix of the entire sensor arrangement. All elements of the matrix contain a measurement value pair consisting of an X measurement value and Y measurement value, e.g., [$U_{ik\,X}$, $U_{ik\,Y}$]. In the case of no contact, it is always clearly greater than in the case of contact with a sensor element (**1**). In the case of touching individual sensor elements (**1**) on the main diagonal of the arrangement, the value pair elements are equally great, e.g., [$U_{ik\,X} = U_{ik\,Y}$]. However, they are differentiated depending on their position on the main diagonal of the matrix. In the case of the touch to a single sensor element (**1**) of the arrangement, which is geometrically reflected on the main diagonal of the matrix, their measurement signal pairs also reflect each other, e.g., [$U_{ik\,X} = U_{ik\,Y}$] and [$U_{ik\,Y} = U_{ik\,X}$], in each case X value against the Y value.

List of indicators

1. capacitive sensor element
2. Single surface
3. supply element
4. quadruple pole capacities $\mathbf{C_{vp}}$
5. Operator's finger or object, capacitive ground
6. non-conductive material, e.g., glass
7. capacities against earth potential $\mathbf{C_E}$
8. coupling resistors
9. supply source or generator
10. common measurement signal junction X axis
11. common measurement signal junction Y axis
12. evaluation electronics
13. microcontroller
14. input stage
15. diamond structure

Patent claims

1. Through electrically non-conductive materials operational touch sensitive device with the capacitive measurement effect for determining the position coordinates of a touch of the non-conductive material **characterized by** the fact that

   A test signal is wired to the orthogonal side edges of a homogeneously structured field from a multiplicity of individual, equal, electrically conductive surface elements and the measurement signals are coupled out on the orthogonal side edges, whereby

   The partial electric inhomogeneity through at least parasitic capacitive couplings against earth potential or a constant reference potential, generated by the operation will be detected by the measurement signals.

2. Touch sensitive device for determination of position coordinates consisting of the following:

A preferably single-layer, matrix, orthogonal arrangement of individual capacitive sensor elements (**1**) receiving a viable common electric signal supply on two orthogonal to each other edges through coupling resistors (**8**) from a source or a generator (**9**), whereby the individual capacitive sensor elements (**1**) consist of four individual surfaces of an electrically conductive material, or a corresponding coating;

A measurement junction (**10**), commonly and viably formed through the coupling resistors (**8**), of the voltage U_X or of the current I_X, which forms the measurement value against the signal mass of the earth potential for determination of the X position of the contact;

A measurement junction (**10**), commonly and viably formed through the coupling resistors (**8**), of the voltage U_Y or of the current I_Y, which forms the measurement value against the signal mass of the earth potential for determination of the Y position of the contact; and

A matrix of orthogonal arrangement of capacitive sensor elements (**1**) guarded against the direct contact in such a way by the isolating, electrically non-conductive material (**6**) that in each case capacities can be created between the at least parasitically capacitively grounded operator's finger or object (**5**) and the individual surfaces (**2**) of the capacitive sensor elements (**1**) as well as among the individual surfaces (**2**), whereby the non-conductive material (**6**) can serve at the same time as a carrier of the capacitive sensor elements (**1**).

3. Device in accordance with claim 1 and 2, whereby the individual surfaces (**2**), connected with each other by the supply wires (**3**) and, therefore, remaining at the electrically equal potential, in each case consisting of two adjacent capacitive sensor elements (**1**) do not need to have the same distance between each other and, therefore, permit the construction of keyboards.

4. Device in accordance with claim 1 and 2, whereby the individual surfaces (**2**) under the electrically equal potential consisting in each case of two adjacent capacitive sensor elements (**1**) make a contact not through the supply wires (**3**), but are directly connected or in contact with each other so that an extremely simple diamond structure (**15**) is created so that a continuous gap-free position coordinates determination of a touch location can be calculated from the measurement values.

5. Device according to the claim 1, 2, and 4, whereby a software function linked to the location coordinates is assigned and performed after the operator touches corresponding symbol represented in a suitable way on the side accessible to the operator.

6. Device in accordance with claim 1 through 5, whereby the characteristics of the signal of the supply source or of the supply generator (**9**) are either a current or a voltage signal.

7. Device in accordance with claim 1 through 5, whereby the characteristics of the measurement signals is either current of a voltage signal.

8. Device in accordance with claim 1 through 7, whereby the capacitive sensor elements (**1**) and their wirings (**3**) are made transparent.

9. Device in accordance with claim 1 through 7, whereby the conductive material of the capacitive sensor elements (**1**) and their wirings (**3**) are made of copper whose structures are etched from a plastic material coated with copper.

10. Device in accordance with claim 1 through 9, whereby the evaluation electronics (**12**) consists of a generator (**9**), microcontroller (**13**) and the input stage (**14**), whereby the microcontroller (**13**) of the generator (**9**) controls through an amplitude and/or phase control and takes over the communication with the peripheral devices like PC, and whereby there are only three shielded or unshielded wire connections between the preferably single-layer, matrix, orthogonal arrangement of individual sensor elements (**1**) and evaluation electronics.

11. Device in accordance with claim 10, whereby the characteristic of the signal from the supply source or of the supply generator (**9**) is a voltage signal and both measurement signal inputs of the input stage (**14**) are implemented as high-impedance operation amplifier stages.

12. Device in accordance with claim 10 and 11, whereby the measurement signals between the input stage (**14**) and the microcontroller (**13**) are additionally subjected to a voltage-frequency conversion.

13. Process of the touch position coordinate determination comprising the following steps and linkage criteria:

    Supply of a signal through the supply generator (**9**) in the preferably single-layer, matrix, orthogonal arrangement of individual capacitive sensor elements (**1**) in the described way:

    Measurement of the values on a common measurement signal joint X-axis (**10**) and on a common measurement signal joint Y-axis (**11**) by the evaluation electronics (**12**);

    A value pair, e.g., [$U_{ik\,X}$, $U_{ik\,Y}$] is assigned to each individual sensor element (**1**) of the matrix arrangement;

    Whereby in the case of no contact with the arrangement, these values are equal and are greater then in any conceivable case of a touch of the matrix orthogonal arrangement of individual capacitive sensor elements (**1**);

    Whereby in the case of touching individual matrix elements on the diagonal of the arrangement, the value pairs of the matrix are equal, e.g., [$U_{ik\,X} = U_{ik\,Y}$] but differ among themselves depending on their position on the main diagonal of the arrangement;

    Whereby in the case of touching an individual matrix element of the arrangement, which is geometrically reflected on the main diagonal of the matrix and whose measurement signal values are e.g., [$U_{ik\,X} = U_{ik\,Y}$] and [$U_{ik\,Y} = U_{ik\,X}$] can also be reflected by switching each X value against the Y value;

    A unique determination of the XY position coordinates of a touch of the preferably single-layer, matrix, orthogonal arrangement of individual capacitive sensor elements (**1**) by the microcontroller and transfer of these data to an e.g., PC.

Attached 8 pages of drawings